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COMPARATIVE ECONOMIC EVALUATION OF PELLETED CONCENTRATE FEEDS INCORPORATED WITH MORINGA (*MORINGA OLEIFERA*) AND HEDGE LUCERNE (*DESMANTHUS VIRGATUS*) LEAVES IN CAMEL (*CAMELUS DROMEDARIUS*) CALVES

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ABSTRACT

The present study evaluated the comparative economic efficiency of pelleted concentrate feeds incorporating with 10% Moringa (T_2) and 10% Hedge lucerne (T_3) leaves in camel calves. Growth performance relative to digestible crude protein intake (DCPI) and total digestible nutrient intake (TDNI), along with feed cost per day and cost per kg weight gain, were assessed. Although DCPI and TDNI did not differ significantly among treatments, T_3 showed numerically higher nutrient-use efficiency. Daily feed cost was highest in T_2 due to the relatively higher production and procurement cost of Moringa leaves, whereas T_3 incurred moderate daily costs. Notably, the lowest cost per kg weight gain was observed in the Hedge lucerne-based diet (Rs 77.00 ± 4.45), indicating superior economic efficiency. When interpreted alongside biomass productivity, Hedge lucerne with its high annual dry matter yield and perennial growth habit emerged as a more economical and scalable leaf resource compared to Moringa. The results demonstrate that Hedge lucerne-incorporated pelleted concentrate feeds offer a cost-effective and sustainable alternative protein source for livestock production system without compromising growth efficiency.

Key words : Economic efficiency, Pelleted concentrate feed, *Moringa oleifera*, *Desmanthus virgatus*, Feed cost.

Introduction

Increasing costs and fluctuating availability of conventional concentrate ingredients, particularly oilseed cakes, pose significant challenge for economic sustainability of ruminant production systems (FAO, 2020; Makkar, 2023). This limitation is more pronounced in camel husbandry, where feed costs constitute a major share of total production expenses, especially under arid and semi-arid conditions. Moreover, the country is now facing a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients (IGFRI, Vision 2050). Consequently, attention has increasingly shifted toward locally producible, high-biomass, protein-rich alternative feed resources that can be integrated into complete feeding systems. *Moringa oleifera* is widely recognized for its rapid growth, high crude protein content and nutraceutical value. Under intensive management, Moringa produces dry matter yields ranging from 4.2 to 8.3 t/ha, with a short cut interval of approximately 40 days, making it suitable for frequent harvest systems (Nouman *et al*., 2014). However, its relatively lower biomass yield per unit area and higher establishment and management costs can influence its economic feasibility when used as a large-scale protein source. Conversely, Hedge lucerne is a perennial tropical legume well adapted to dryland environments, producing 23-35 t DM/ha/year (Gutteridge and Shelton, 1994), with reported biomass yields as high as 853.7 q/ha/year under favorable conditions (Kumar *et al*., 2021). Its high crude protein content, favorable fibre characteristics, mineral richness and good digestibility make it a viable alternative to conventional oilseed cakes (Cook *et al*., 2005). Furthermore, ruminants have demonstrated good acceptance and utilization of *Desmanthus* fodder as a

leguminous protein source (Radhakrishnan *et al*., 2007).

Pelleted concentrate feeding systems provide an effective platform for incorporating such unconventional leaf meals by improving nutrient uniformity, reducing selective feeding and enhancing feed efficiency. Although, Moringa and Hedge lucerne have been widely studied for their nutritional and physiological effects, their comparative economic efficiency accounting for biomass productivity and cost per unit gain remains inadequately explored in camel calves. Therefore, the present study focus to assess the economic viability of pelleted concentrate feeds incorporating Moringa and Hedge lucerne leaves in growing camel calves.

Materials and Methods

Location and Climatic conditions

The Research centre is located in the Jorbeer area of Bikaner city. It is situated at Latitude: 28° 01' North and Longitude: 73° 11' East with Time zone: GMT +05:30 hours. The soil type is loose and sandy. The climate is mostly dry and hot with annual rainfall in the range of 260-440 mm. The temperature ranges between 30-48^{0}C in summer and between 4-28^{0}C in winter season. The experiment was conducted in May-December 2024, during which the minimum and maximum ambient temperature ranged from 15^{0}C and 41^{0}C, respectively. Relative humidity varied from 22 to 60%.

Experimental diets and design

Three iso-nitrogenous pelleted concentrate feeds were formulated on DM basis using conventional roughages (T_1), 10% Moringa leaf incorporated pelleted concentrate feed (T_2), and 10% Hedge lucerne leaf incorporated pelleted complete feed (T_3). The pelleted concentrate feeds were prepared with a roughage-to-concentrate ratio of 80:20. The roughage component consisted of groundnut straw (*Arachis hypogea*) and guar straw (*Cymopsis tetragonaloba*) mixed in equal proportion. Nutrient requirements of the experimental animals were formulated to meet ICAR (2013) standards. Fifteen healthy un-weaned female camel calves of similar age (3-4 months), body weight, and uniform conformation were selected from the camel herd of ICAR-NRCC, Bikaner and randomly allotted 5 each to three treatment groups for a feeding trial of 180 days.

Feeding trial

During the entire experimental period of 180 days, measured quantity of pelleted concentrate feed was offered to each treatment group every morning and evening at 10.00 AM and 04.00 PM, respectively. Suckling of whole milk was also offered to calves every morning for 15 minutes. The quantity of feed offered and left over quantity were recorded on daily basis to assess the daily feed consumption of calves. Samples were collected to estimate the moisture content of the feeds offered and left-over feed, which were subjected to analysis for dry matter and organic matter consumption at fortnight interval. Similarly, water was provided in marked bucket once daily.

Cost evaluation

The economics with respect to performance of animal is the appropriate basis for the exploitation of new technology developed or new feed ingredient is used, particularly when un-conventional feed resources are being included to make ration economic and to have profitable livestock returns. Based on the market pricing of feed ingredients, the cost evaluation of experimental pelleted concentrate feeds has been calculated. The cost of pelleted concentrate feed and additional costs associated with producing pelleted concentrate feed, such as depreciation, interest on average investment, maintenance, repair, labor and electricity has also taken into account.

Statistical analysis

The data generated during the experiment was subjected to statistical analysis using by SPSS statistical software (2011) Version 20.0 and the data were analyzed using one-way and two-way ANOVA procedures for difference between treatments and periods. The difference between means was declared significant at $P<0.05$ and $P<0.01$. Duncan's multiple range test was conducted for comparing among the averages.

Results and Discussion

The crude protein and crude fibre composition of Moringa leaves were 25.06% and 17.35%, whereas the corresponding values for Hedge lucerne leaves were 26.30% and 14.45%, respectively. Growth efficiency expressed per unit of digestible crude protein intake (DCPI) and total digestible nutrient intake (TDNI) did not differ significantly among treatments (Table 1). However, Hedge lucerne-based pellets (T_3) showed numerically higher DCPI and TDNI values, indicating slightly improved nutrient conversion efficiency. Economic analysis revealed significant differences in cost of feed consumed daily (Table 2). Moringa-based diet (T_2) had highest daily cost, followed by Hedge lucerne (T_3). Importantly, when costs were expressed relative to body weight gain, T_3 recorded the lowest cost per kg gain, followed by T_2 and T_1, highlighting superior economic efficiency of Hedge lucerne inclusion despite moderate

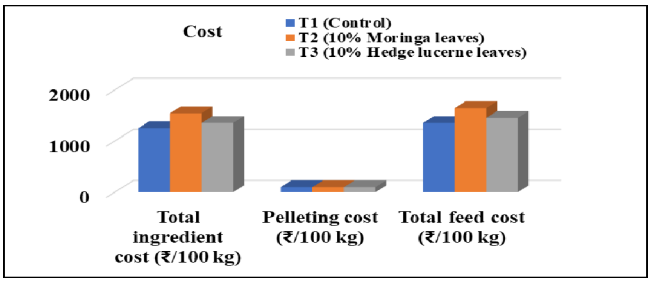

Fig. 1 : Total feed cost across treatments.

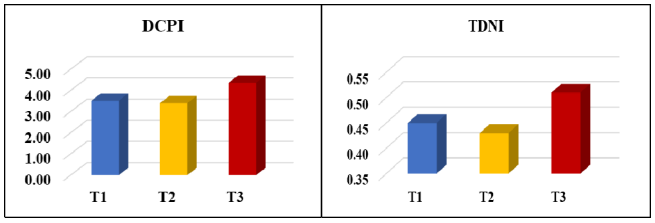

Fig. 2 : Growth gain per DCPI and TDNI (kg/d).

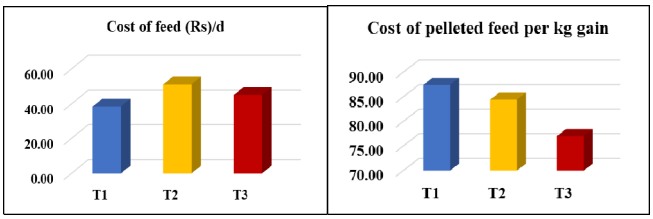

Fig. 3 : Cost evaluation of pelleted feed per kg gain.

Table 1 : Cost of total ingredients and total feed cost of experimental pelleted concentrate feeds.

Treatment	Total ingredient cost (Rs/100 kg)	Pelleting cost (Rs/100 kg)	Total feed cost (Rs/100 kg)
T_1 (Control)	1254.3	100	1354.3
T_2 (10% Moringa leaves)	1545.5	100	1645.5
T_3 (10% Hedge lucerne leaves)	1355.5	100	1455.5

Table 2 : Effect of leaves incorporated pelleted feed on live weight gain per unit of digestible protein and energy intake (kg/d).

Attributes	T_1	T_2	T_3	SEM	P value
DCPI(Digestible Crude Protein Intake)	3.52±1.22	3.40±1.04	4.36±1.73	0.34	0.500
TDNI(Total Digestible Nutrient Intake)	0.45±0.17	0.43±0.13	0.51±0.19	0.04	0.701

Table 3: Cost evaluation of pelleted feed per day (Rs) and gain

Attributes	T_1	T_2	T_3	P value
Cost of feed (Rs)/d	38.51^{a}±0.21	51.17^{c}±1.67	45.13^{b}±0.61	0.001
Cost evaluation of pelleted feed per kg gain	87.43±2.63	84.41±3.18	77.00±4.45	0.139

Means within a row bearing different superscripts (a, b, c) differ significantly (P < 0.05)

daily feed cost. The absence of significant differences in DCPI and TDNI across dietary treatments indicates that incorporation of Moringa or Hedge lucerne leaves into pelleted complete feeds did not adversely affect nutrient utilization efficiency. The numerically higher nutrient-use efficiency observed in the Hedge lucerne-based diet suggests more favorable synchronization between protein and energy supply, which is consistent with its balanced fibre-protein complex and good ruminal degradability.

Economically, the higher daily feed cost associated with Moringa-based pellets can be attributed to lower biomass yield per unit area and higher harvesting frequency, despite its superior nutrient density. Although Moringa can be harvested frequently at 40-day intervals; its dry matter yield (4.2-8.3 t/ha) is substantially lower than that of Hedge lucerne, which produces large quantities of biomass annually due to its perennial growth habit (Nouman *et al.*, 2014; Gutteridge and Shelton, 1994). Hedge lucerne's markedly higher biomass yield reported up to 853.7 q/ha/year translates into lower cost per unit dry matter produced; thereby reducing cost of feed ingredients when scaled for pellet feed manufacture (Kumar *et al.*, 2021). This production advantage explains the lowest cost per kg weight gain observed in T_3, despite similar nutrient intake and growth efficiency across treatments. Moreover, Hedge lucerne can partially replace conventional oilcakes without adversely affecting digestibility or animal performance, indicating its potential as a cost-effective protein source (Cook *et al.*, 2005; Radhakrishnan *et al.*, 2007). Inclusion of *Moringa oleifera* meal in ruminant ration reduces the feed cost/kg BW gain (Ali, 2017; Yusuf *et al.*, 2018; Anushree, 2021; Chaudhary, 2021; Sherasiya, 2021). Similarly, Shankhpal *et al.* (2019) reported that the daily feed cost was decreased significantly (P<0.01) in ration when hybrid napier replaced by green *Moringa*. Sonkar *et al.* (2020) reported significantly lower feeding cost per kg milk production in cows when concentrate was replaced by dried *Moringa oleifera* leaves at different level (10 and 20 %). The higher net profit recorded by Sonawane (2018) in goat by feeding hedge lucerne, reason might be due to the least total cost of feed consumed.

Overall, these findings highlight that biomass productivity, rather than nutrient concentration alone,

which plays a key role in determining the economic efficiency of alternative feed for evaluation of livestock feeding system.

Conclusion

Based on results obtained in the present investigation, it could be concluded that tree leaves i.e. Moringa and Hedge lucerne can be utilized successfully @ 10% in the feeding of camel calves by blending with other reliable ingredients in the form of pelleted concentrate feed. Incorporation of hedge lucerne (*Desmanthus virgatus*) leaf in pelleted concentrate feeds resulted in the lowest cost per kg body weight gain in camel calves which revealed its superior economic efficiency compared to Moringa leaf based and conventional diets. These results further indicated that the cost of production of Hedge lucerne was lower due to its higher tillering ability and ease of collection and drying of plant material, making it advantageous for use in livestock feeding. These findings support the strategic use of high-biomass leguminous fodders to improve profitability and sustainability of livestock feeding systems. Therefore, Hedge lucerne leaf can be used as cheaper feed resources and alternative to Moringa leaf for feeding of livestock in future.

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